HUMIDITY SENSING APPARATUS

The invention disclosed herein relates generally to dew point hygrometers, and more specifically to such hygrometers utilizing integrated circuit cooling apparatus of a type in which a Peltier device is formed partially on a heat sinking substrate.

One type of hygrometer which is already known utilizes an absorbent body formed of a material such as a ceramic or high polymer. Such a hygrometer employs changes in the resistance or capacitance values of the absorbent body due to humidity in the atmosphere, and has the advantage of a very simple configuration. However, since pollutants in the atmosphere will adhere to the absorbent body during operation, changes occur in the material which constitutes the body, so that the operation does not remain stable over a long period of time. For this reason, depending upon the specific operating environment, substantial errors in the humidity indications produced by such apparatus will occur after it has been in operation for approximately one to two months.

It is well known that a dew point hygrometer does not present the type of problem just described. One specific configuration for a dew point hygrometer is as follows. A cooled mirror surface is employed, which is cooled by means such as Peltier cooling. Water droplets are thereby formed on the cooled mirror surface, causing that surface to become clouded, thereby producing changes in the degree of reflection of light from the mirror surface, and these changes are detected. In this way, the dew point temperature is detected as the temperature at which the mirror surface becomes clouded. By thus determining the dew point temperature, the water vapor saturation pressure at a specific temperature can be defined. From this the water vapor saturation pressure of the ambient atmosphere, i.e., the absolute humidity, can be obtained. If it is desired to obtain the relative humidity, this can be determined by sensing the ambient atmospheric temperature and utilizing this temperature value to calculate the relative humidity.

Such a hygrometer operates on the basis of condensation of water molecules, i.e., operates purely on the basis of changes in H_2O resulting from temperature variations, and does not rely on changes in the physical characteristics of the sensor element with respect to temperature. Thus, it is unlikely that deviations in the measured values will occur due to operation even in a highly polluted environment over a long period of time.

In recent years, the Delft Science University in Holland has announced research on a dew point hygrometer which utilizes the Peltier effect. This incorporates a water droplet sensor which is integrated with a temperature sensor, as a single element. The latter research was described in the P.P.L. REGTIEN, Solid-state Humidity Sensors, Sensors and Actuators, 2 (1981/82) 85–95. In this dew point hygrometer, a silicon substrate has a temperature sensor formed on the rear face thereof, while a water droplet sensor is formed on the front face of the substrate. This water droplet sensor is made up of mutually opposing comb-shaped electrodes. In this way, an element is formed which integrates a water droplet sensor and a temperature sensor. In addition, this element is mounted on a Peltier cooling unit, so that formation of water droplets from water vapor in the atmosphere is produced due to cooling by the Peltier effect, and these water droplets can be detected, while moreover the temperature at which these water droplets are formed can be measured.

Specifically, a sudden change in the electrical capacitance between the mutually opposing electrodes occurs as a result of formation of the water droplets. The cooling action of the Peltier cooling unit is controlled such as to maintain the operating point at the dew point, i.e., at the point where this sudden change in capacitance occurs. At the same time, the dew point temperature (i.e., the temperature at which this condition occurs) is detected by the temperature sensor which is formed on the silicon substrate.

It is a feature of the prior art type of hygrometer described above that an element is utilized having a water droplet sensor and a temperature sensor integrated on a single substrate, employing integrated circuit technology, while the entire element is cooled by a Peltier cooling unit. However, since the entire hygrometer element must be cooled, a large amount of electric current is necessary for the cooling operation so that the overall power consumption of the Peltier cooling unit is high. In addition, it is necessary to efficiently dissipate the heat which is generated by the cooling unit, so that there are severe design constraints upon the sensor as a whole, including the cooling unit. For these reasons, such as a hygrometer is not suitable for general usage.

SUMMARY OF THE INVENTION

The present invention is a humidity sensing element comprising a substrate having formed thereon a first metallic pattern and a second metallic pattern arrayed in an alternating manner, with Peltier cooling means formed on an insulating layer overlaying the substrate, said Peltier cooling means being made up of junctions formed at successively occurring mutually joined end portions of said first metallic pattern and end portions of said second metallic pattern, with said successive junctions being alternately disposed at a central region and at a peripheral region of said substrate respectively, and further comprising water droplet detection means formed upon a insulating layer formed over a first group of said junctions, and with a central portion of said substrate being removed.

A humidity sensing element according to the present invention is designed to overcome the problems of the prior art as described above. To this end, a humidity sensing element according to the present invention is formed upon a substrate which has a central portion thereof removed, with water droplet sensing means being disposed upon a cooling section which is formed by Peltier cooling means. The Peltier cooling means are disposed in a central region of the humidity sensing element.

Due to the fact that the cooling section of such a humidity sensing element is formed by Peltier cooling means which are disposed in a central cut-out region of the substrate, with the cooling section being thereby thermally insulated, it is possible to operate the humidity sensing element by employing only localized cooling with a low level of current. In addition, it is possible to utilize the Peltier cooling means also as temperature detection means, by appropriate switching of the Peltier cooling means using an external circuit. By using the temperature thus measured and an output signal from the water droplet sensing means, the ambient atmospheric humidity can be measured.